cover a wide variety of topics related to the use of nitrogen by plants.

Traditional genetics and plant breeding have seldom been applied to increasing symbiotic N_2 fixation. Two papers by G. H. Heichel and D. K. Barnes and their co-workers decribe and evaluate a breeding program to enhance fixation by alfalfa. These scientists demonstrated that genetic differences for fixation do exist in alfalfa lines. Plant traits, including nodule mass, shoot dry weight, and fibrous roots, were positively correlated with nitrogen-fixing ability. Though it is obvious that many plant genes are involved in the symbiosis, significant increases in fixation were achieved after only a few generations of selection. It was important to test selections in the field, with appropriate rhizobial inoculant. This research demonstrates the potential for increasing N_2 fixation in agriculture. The authors recommend a similar collaboration of breeders, microbiologists, and plant physiologists for each major legume crop.

Symbiotic fixation is not "free fertilizer," and several papers deal with the energetics of N_2 fixation. There is some evidence that symbiotic fixation by legumes requires more energy than utilization of soil nitrate. It has been difficult till now, however, to estimate the metabolic cost of nodule formation and maintenance, or the cost of *p*H control during assimilation of nitrate. D. K. McDermitt and R. S. Loomis propose a novel method of determining, on the basis of the elemental composition of a legume and its growth yield, the cost of growth on different nitrogen sources.

The nitrogen-fixing enzyme nitrogenase reduces protons to H_2. This contributes to the energy cost of fixation if H_2 escapes the nodule. Some strains of *Rhizobium* have an uptake hydrogenase (Hup), which may permit a partial recovery of the energy lost in H_2 formation. A survey of soybean nodules from every soybean-producing area in the United States indicated that 75 percent were infected by rhizobial strains lacking the enzyme (Hup^-). It is remarkable that the *R. japonicum* strains in most commercial inoculants for soybean are similarly Hup^-. The gene for Hup is carried on a rhizobial plasmid, so it should eventually be possible to incorporate hydrogen uptake activity into efficient strains adapted for each region.

Denitrification is the process whereby some soil bacteria convert nitrate to N_2 or volatile nitrogen oxides. Up to one half of added nitrate fertilizer may be lost to the atmosphere in this way. Many of the bacterial species involved do not grow well in vitro, and the assays for some enzymes are difficult. Only a handful of scientists have persisted in studying this subject. Despite the major role of denitrification in decreasing soil fertility, the study of it is generally underfunded and unrecognized. For the nonspecialist, the 100 pages here provide a very good introduction to the topic.

Much of the research presented in the book has appeared in journals. Most of the papers are too short to adequately review their topics. Of little value as a reference book, this work may inform the casual browser.

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Paleobotany

Geobotany II. Proceedings of a conference, Bowling Green, Ohio, March 1980. Robert C. Romans, Ed. Plenum, New York, 1981. viii, 264 pp., illus. $39.50.

Geobotany II includes papers presented at the 1980 geobotany conference. (An earlier conference yielded *Geobotany*.) It includes all the papers presented, except for those by M. B. Davis, J. A. Doyle, and A. H. Knoll, for which only abstracts are included. (Doyle and Davis have presented similar ideas elsewhere, but Knoll's abstract on the paleoecology of Pre-Cambrian "microbes" is a bit frustrating—one would like much more. What business has an abstract—by nature an evanescent thing—in a book?)

The papers are mostly in the general area of paleobotany-paleopalynology. There is one ecological study (R. W. Dexter) of plant succession of a disturbed area at Cape Ann, Massachusetts, which really does seem out of place next to papers on the cupule organization of the earliest seed plants (L. C. Matten and W. S. Lacey) and the anatomy of two Paleogene woods (W. H. Blackwell *et al.*), though not so far out of line with a study of environmental changes in time, shown by "peat petrology" in South Florida (P. R. Kremer and W. Spackman), and one on the postglacial history of prairie fens and bog fens in Ohio (R. L. Stuckey and G. L. Denny). A number of the papers are pollen-analysis–based studies of Pleistocene and Holocene sections in various parts of North America (papers by R. E. Bailey and P. J. Ahearn; J. Terasmae; J. F. P. Cotter and G. H. Crowl; W. J. Merry; P. A. Delcourt and H. R. Delcourt). These are conventional pollen-analysis studies, but an editorial novelty is introduced in the papers by Cotter and Crowl and Bailey and Ahearn: foldout diagrams, as well as the *same* diagrams in page size, with a note that a full-size diagram follows. Surely no journal editor would have allowed that.

The two papers that were most interesting to me were those of G. R. Upchurch, Jr., and J. A. Doyle on the paleoecology of two Cretaceous conifers, *Frenelopsis* and *Pseudofrenelopsis*, that produced *Corollina* (*Classopollis*) pollen, showing that the two conifer genera had quite different ecological requirements; and a fascinating series of seven vegetation maps, 40,000 years ago to present, by Delcourt and Delcourt, based on paleobotanical-paleopalynological data. Unfortunately the maps, though very useful, are flawed and frustrating, because the shading on them is at a different scale from those in the keys and in a couple of cases even of a different pattern. I have colored mine with crayons as an aid but am still not sure I have it right. Again, a journal editor and referees would have caught this sort of thing. There are other difficulties, for example, unexplained boundary lines on maps in Stuckey and Denny. A final reason why these papers should have been submitted to ordinary journals is that there is buried on p. 213 the description by Blackwell *et al.* of a new genus (*Floroxylon*) not even mentioned in the abstract. Publication of new names in unconventional places is not uncommon but is a nomenclatural nightmare to be avoided.

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Peat Bogs

Peat Stratigraphy and Climatic Change. A Palaeoecological Test of the Theory of Cyclic Peat Bog Regeneration. K. E. Barber. Balkema, Rotterdam, 1981 (U.S. distributor, Merrimack Book Service, Salem, N.H.). xii, 220 pp., illus., + plates. $29.

A long-prevailing explanation for the upward growth of raised bogs involves cyclic hummock-hollow regeneration: hollows between hummocks are characterized by rapid growth of *Sphagnum* species, whereas the dry hummocks are relatively dormant; hollows thus become hummocks, and the microtopography is reversed cyclically many times as the peat accumulates. This book, an outgrowth of a University of Lancaster dis-

sertation, records an attempt to test this hypothesis by detailed stratigraphic studies of peat sections at Bolton Fell Moss in northwestern England. The stratigraphy of 14 peat faces a few meters long and 50 to 100 centimeters deep, representing about the last 2000 years, was sketched in the field to show in detail the horizontal continuity of pool and hummock facies, and peat samples taken from 21 monoliths were analyzed microscopically to identify the different *Sphagnum* species diagnostic of various pool depths, as well as *Eriophorum* (cottongrass) and *Calluna* (heath), the principal plants of dry hummocks. A detailed pollen diagram prepared from one peat face was used to provide time control for pollen counts from other peat faces, along with radiocarbon dating.

No patterns of hummock-hollow alternation could be detected as a result of these studies. Instead, the author identifies changes from dry hummock communities to wet lawns, or from wet lawns to pool associations, as a result of a rising water table over the entire bog in response to climatic change. During dry intervals the peat becomes decomposed (humified), and the result is a "recurrence surface," long ago described by Granlund. By correlating these surfaces from one peat face to another with the aid of pollen analysis and radiocarbon dating, Barber places the wet intervals at A.D. 900 to 1100, 1320 to 1485, and 1745 to 1800, similar to the periods identified by Lamb on the basis of English historical records.

The book presents a great deal of descriptive detail on the stratigraphy of individual peat faces, but the sketches and stratigraphic diagrams are difficult to read because of small lettering and confusing symbols and are in an illogical order. The absence of an index and a list of illustrations requires repeated searching for cross-referenced comments. The text is also difficult to read because several interpretations and conclusions about paleoenvironments are reached before the major macrofossil evidence is presented. The taxonomy and ecology of *Sphagnum* taxa are incompletely presented in the chapter on methods, but they are more fully developed in the chapters on results and discussion. Bits of information on the ecology and historical phytogeography of *Sphagnum imbricatum* appear in four different parts of the book.

Proper identification of fossil *Sphagnum* species is essential in any studies of peat stratigraphy that attempt to reconstruct microhabitats. The methods used in the work reported in the book apparently did not include staining and sectioning, which are the only satisfactory techniques for distinguishing pore patterns and other diagnostic anatomical characters of certain key species.

The book opens with a very long literature review on the history of Osvald's hummock-hollow hypothesis of peat growth in raised bogs. In many respects this is the best-written and most valuable part of the book. Otherwise, the study illustrates the advantage of multiple stratigraphic analyses of numerous peat faces (in contrast to cores) in reconstructing changing conditions of bog growth. It would seem to lay to rest the Osvald hypothesis for hummock-hollow regeneration and to indicate the high potential of raised bogs to record climatic fluctuations spaced a few centuries apart.

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High Energy Physics

Neutrino 81. Proceedings of a conference, Maui, Hawaii, July 1981. R. J. CENCE, E. MA, and A. ROBERTS, Eds. University of Hawaii Department of Physics and Astronomy, Honolulu, 1981. In two volumes. xviii, 510 pp., illus., and xiv, 512 pp., illus. Paper, $35.

The summer of 1981 saw the eleventh in a series of international conferences on neutrino physics and astrophysics, a tradition that stretches back to Moscow in 1968. In contrast with the 1980 proceedings, which reported the (possible) detection of neutrino mass and neutrino oscillations, there are no exciting new experimental results reported on in the 1981 proceedings. In fact, despite the furor over and the importance of these phenomena, because of systematic problems there are still no conclusive answers in either case, and the status of the phenomena is discussed in the book in progress reports and review papers. Nonetheless, these experimental hints have prompted a large number of new theoretical calculations.

One of the important new theoretical accomplishments comes from the consideration of neutrino masses in cosmology. Here, they allow escape from an inconsistency in the hot big-bang model: The grand unified models that yield a net baryon number for the universe naturally predict only so-called adiabatic density perturbations (parallel in both matter and radiation), whereas cosmological nucleosynthesis requires a low baryon density in the universe to avoid the making of too much helium and not enough deuterium. Yet, the observed clumping of matter into galaxies and clusters seems to require a high density and large density fluctuations $\Delta\rho/\rho$ at the time of the decoupling of the background radiation, which implies temperature fluctuations $\Delta T/T$ in the microwave background larger than present observational limits. A neutrino mass in the range few to several tens of electron volts allows reconciliation of all these requirements, as is discussed in the section of the book on cosmology. The book contains some discussion of, not to say argument about, the status of solar neutrinos.

The book contains a major discussion of axions. The axion, which is a pseudoscalar Goldstone boson from the breaking of a chiral symmetry that allows one to "understand" the strong limits on CP (charge-conjugation, parity) conservation in quantum chromodynamics (QCD), has been in and out of favor for some time. There is a new manifestation of the axion in the context of grand unification that avoids the problem the "standard" axion has with the stability of stars. Faissner reports on "Evidence for axions or something like that" at $m_a = 250 \pm 100$ keV, whereas from an independent search Zehnder concludes that axions with $m_a > 160$ keV are not allowed. The new axion is possibly important in supernovas.

High-energy neutrino experiments are continually refining our understanding of the structure of electroweak interactions. The refinement includes a more and more precise determination of the Weinberg angle in the SU(2) × U(1) model: $\sin^2\theta_w = 0.215 \pm 0.012$ experimentally (taking into account effects of electroweak radiative corrections). Meanwhile, in work on grand unification, calculations of the renormalized value of $\sin^2\theta_w$ have included two-loop diagrams and, in SU(5), yield $0.197 < \sin^2\theta_w < 0.214$, the main uncertainty coming from the QCD scale parameter Λ. Also included in the proceedings is a report by Miyake on the Kolar Gold Field proton-decay candidate events and several other nucleon-decay experiments that have been proposed or are under construction. A significant trend seems to be nonaccelerator experiments, with emphasis on deep underground (or underwater) detectors. The exciting underwater possibilities were given particular focus at this meeting owing to Hawaii's being the site of the proposed DUMAND (Deep Underwater Muon and Neutrino Detector) development.